



MEMORANDUM

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Subject: Cost of Various Water Storage Options

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This memorandum was prepared to enable distribution to more than one congressional office

This memorandum responds to several common questions related to the cost effectiveness of various options to augment water supplies in California. For each response below, CRS has explained the approach and sources. We have also noted those instances in which information needed to respond to a specific question was limited or otherwise unavailable.

If you have additional questions, please contact Charlie Stern at extension 7-7786.

Questions: Cost Effectiveness of Water Supply Options

1. Question: What is the estimated cost per acre-foot of water to be delivered from the proposed Temperance Flat and Sites surface reservoirs?

Response: Temperance Flat Reservoir (also known as Upper San Joaquin Reservoir) and Sites Reservoir (also known as “North of the Delta Offstream Storage,” or NODOS) are at different stages of the Bureau of Reclamation’s (Reclamation) planning process, and neither project’s planning process has been completed. As a result, neither proposal has resulted in a recommended construction option by Reclamation. The estimated cost per acre-foot of water for both projects is currently estimated as a range based on the options under consideration. Such an estimate is based on a combined estimate of annualized construction costs (i.e., construction cost, amortized), plus estimated annual operational costs, divided by estimated project yield (i.e., the amount of water each reservoir is expected to reliably “produce” annually, which is different than storage capacity). These estimates are potentially subject to considerable variability based on a number of factors (e.g., changes to project design, material costs, etc.). The estimates for each project are detailed below. Please note that Reclamation’s actual analysis of projects goes well beyond assessments of the cost per acre-foot of water yield, to also include other benefits.¹

¹These benefits are included in the total Benefit Cost Ratios (BCR) for each project. The BCR is currently considered to be of the highest importance in recommending a project for congressional authorization.

According to the Draft Feasibility Report for the Upper San Joaquin River Storage Investigation, total construction costs for the four options under consideration range from \$2.5 to \$2.6 billion, depending on the option selected. The range of combined annualized costs for amortized construction and operations and maintenance was estimated at \$116 million-\$121 million/year.² The estimated long term average for annual project yield for the options under consideration ranges from 61,000 to 76,000 acre-feet per year (af/yr), depending on the operational scenario used.³ Based on the aforementioned figures and assumptions, the combined development and operational cost per acre-foot for water from the Upper San Joaquin reservoir would be \$1,553-\$1,902.

According to 2013 documents, estimated construction costs for the four options under consideration for Sites/NODOS Reservoir ranged from \$3.6 to \$4.1 billion,⁴ depending on the option chosen. The range of costs for amortized construction and operations and maintenance was \$178-\$204 million/year.⁵ Finally, the same studies projected that the alternatives for Sites/NODOS could potentially result in long term average yield ranging from 425,000 to 488,000 af/year, again depending on the water year and option selected.⁶ Based on these assumptions, the range of costs per acre-foot for water from Sites/NODOS would be \$414-\$444.

2. Question: What is the cost per acre-foot of water developed from Title XVI projects (Bureau of Reclamation water reuse projects)?

Response: There is no official cost estimate or tracking by Reclamation of the average cost per acre-foot for Title XVI water. Estimates for the cost per acre-foot for water reuse and recycling projects are likely to vary widely among projects, and depend considerably on factors such as the size and location of the project, the type of technology being employed, the demand for project water, whether the project produces potable or nonpotable water, and numerous other factors.

Some information on water reuse and recycling projects in general is available from other sources. A 2013 update to the State Water Plan by the State of California noted that the costs per acre-foot of reclaimed water can range from \$300 to \$1,300/af.⁷ However, costs may also exceed the upper estimate, and may have changed considerably since this estimate was made.⁸ A survey by CRS of the estimated costs and expected yields at

² Figures are at 2013 price levels, discounted at the federal discount rate of 3.75% over 100 years. Bureau of Reclamation, *Upper San Joaquin River Storage Investigation Draft Feasibility Report*, Jan 2014, http://www.usbr.gov/mp/sccao/storage/docs/Draft_Feasibility_Report_2014/USJRBSI_Draft_FR_2014_Full_Report.pdf. Hereafter "Upper San Joaquin Draft Feasibility Report."

³ Data from the Upper San Joaquin Draft Feasibility Report, Tables 3.7 and ES-2. Figures do not account for dry/critical years, in which the increase in deliveries is estimated to be considerably less (19,000-30,000 af/yr). Additionally, the report notes that these figures are sensitive to operational parameters and assumptions.

⁴ California Department of Water Resources, *North-of-the-Delta Offstream Storage Preliminary Engineering Design and Cost Estimate*, Dec 2013, p. 4-9. http://www.water.ca.gov/storage/docs/NODOS%20Project%20Docs/Preliminary%20Engineering%20Design%20and%20Cost%20Estimate%20Report/Chapter%204%20Cost%20Estimate%20Feb%202014_JG_022114.pdf. Figures are at 2013 price levels, discounted at the federal discount rate of 3.75% over 100 years. Hereafter "Preliminary NODOS Cost Estimate."

⁵ Preliminary NODOS Cost Estimate, p. 4-9.

⁶ The study also provided a "dry year" yield ranging from 320,000 to 380,000 af/yr.

⁷ California Natural Resources Agency, Department of Water Resources, *California Water Plan, 2013 Update*, Bulletin 160-13, p 12-25. <http://www.waterplan.water.ca.gov/cwpu2013/final/index.cfm#Volume1>. Hereafter *California Water Plan*.

⁸ Although published in 2013, this document also relies on earlier data. A date for the estimate cited in footnote 5 of this memorandum was not available. As technologies improve, marginal costs for a given technology often decrease; however, other (continued...)

several individual Title XVI projects found some projects to be within the aforementioned range.

3. Question: What is the cost per acre-foot of water from existing Reclamation surface reservoirs in the Central Valley Project (CVP)?

Response: Since it is largely operated as a system, a complete picture of the CVP's financing would inherently involve not only the costs for surface reservoirs, but also those for pumps, canals, and appurtenant facilities. However, based on existing information, it is not possible to calculate an aggregate, actual cost per acre-foot of water for CVP surface reservoirs amortized for individual projects.⁹

The CVP is an exceptionally large, multipurpose project¹⁰ whose elements have been constructed at various points in time. Its rate-setting process does not report on the project's cost information in an aggregated and amortized format. An additional difficulty associated with the CVP is that there are no formal estimates of "project yield" that are comparable to the aforementioned figures for future storage and Title XVI projects, respectively. As discussed below, only CVP "deliveries" (which are different than "yield") are available.

Below, CRS has summarized available information that contextualizes: (1) the cost of water from the CVP for contractors, including both agricultural contractors and municipal and industrial contractors (M&I); and (2) the overall cost of the CVP. While these numbers do not provide for a direct comparison with the responses to other options discussed in this memorandum, they show that, in general, CVP water is considerably less costly compared to other options (largely due to the age of its main features).¹¹

The rates paid by agricultural contractors of the CVP vary widely and are based on a construction costs that are allocated to irrigation over a 40-year period (without interest), as well as costs for annual operations and maintenance expenses and related costs. According to the Bureau of Reclamation's 2015 ratebooks, the estimated rates per acre-foot for CVP agricultural water service contractors in water year 2015 ranged from \$9.98 to \$103.73 per acre-foot, and the average rate paid was \$32.39 per acre-foot.¹² The range of rates for the 205 CVP agricultural contractors is displayed below in **Figure 1**. While Reclamation charges many of its contractors the Cost of Service (COS) rate to provide this water, approximately 38 of the 205 CVP agricultural contractors (18%) receive repayment relief from this charges based on their "ability to pay,"¹³ resulting in their

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factors, such as construction labor costs, energy costs, and land costs, depending on the circumstances can also increase or decrease over time.

⁹ In June 2015 CRS requested, and Reclamation declined, to provide a total, inflation-adjusted amortized construction cost figure for the CVP.

¹⁰ The CVP includes 20 dams and reservoirs, and hundreds of miles of canals.

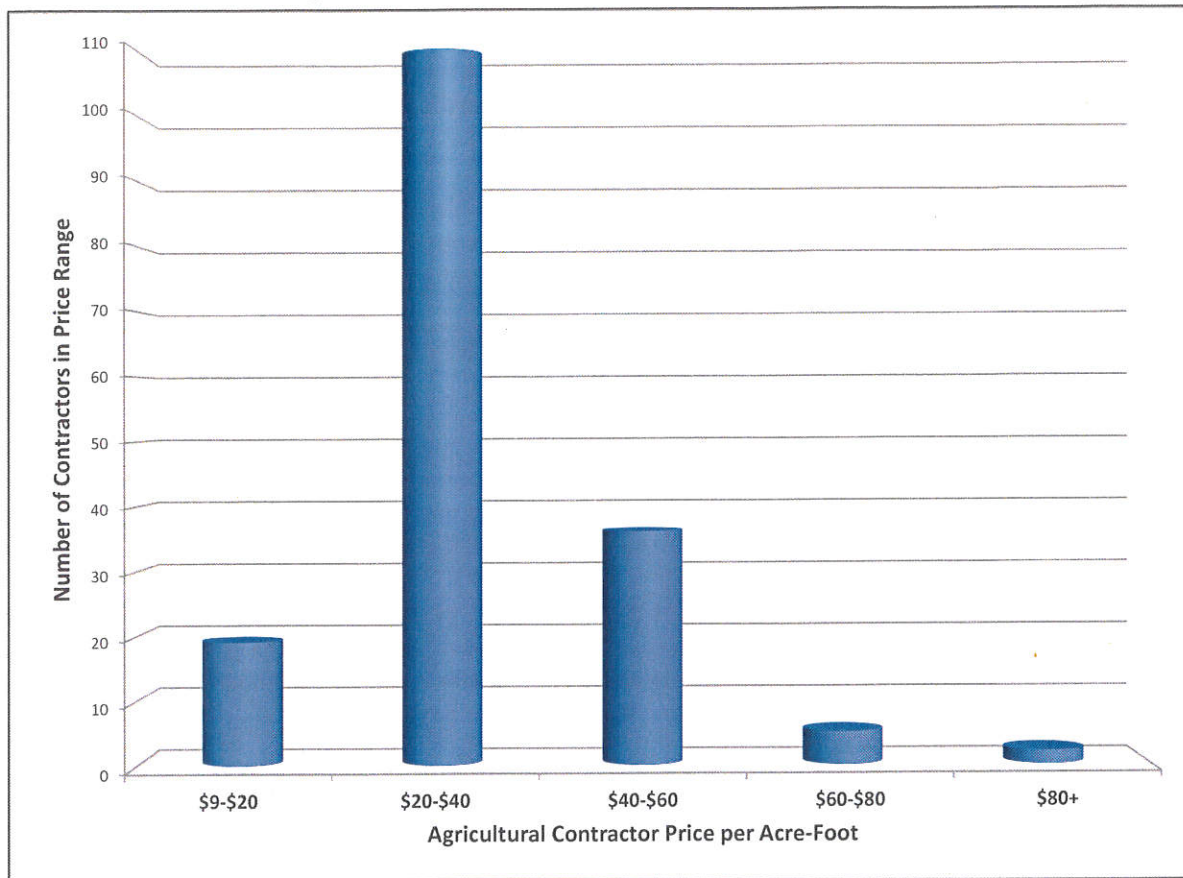
¹¹ Many of the CVP's primary facilities, including its largest storage dam, Shasta Dam, were completed by the late 1950s. Due to relatively low construction costs compared with today, these features yield water at a lower cost than would be possible today.

¹² These rates do not include certain special rates, such as those for Sacramento River Water Settlement Contractors. Bureau of Reclamation, *Schedule of Irrigation Contract, Cost of Service, and Full Cost Water Rates per Acre-Foot by Contractor, 2015 Irrigation Water Rates, Schedule A-1, 2015*, http://www.usbr.gov/mp/cvpwaterrates/ratebooks/irrigation/2015/IRR_2015_Sch_A-1_F.Z17.pdf. These costs do not include certain "special" rates, which are explained in detail at <http://www.usbr.gov/mp/cvpwaterrates/ratebooks/special/2015/index.html>. Average cost calculations based on CRS analysis of Reclamation data.

¹³ Under the Reclamation Projects Act of 1939 Reclamation is authorized to develop special rates based on irrigators' "ability-to- (continued...)

paying rates that are less than the COS. The difference between the COS and the actual contract rate are shown in **Figure 2**.

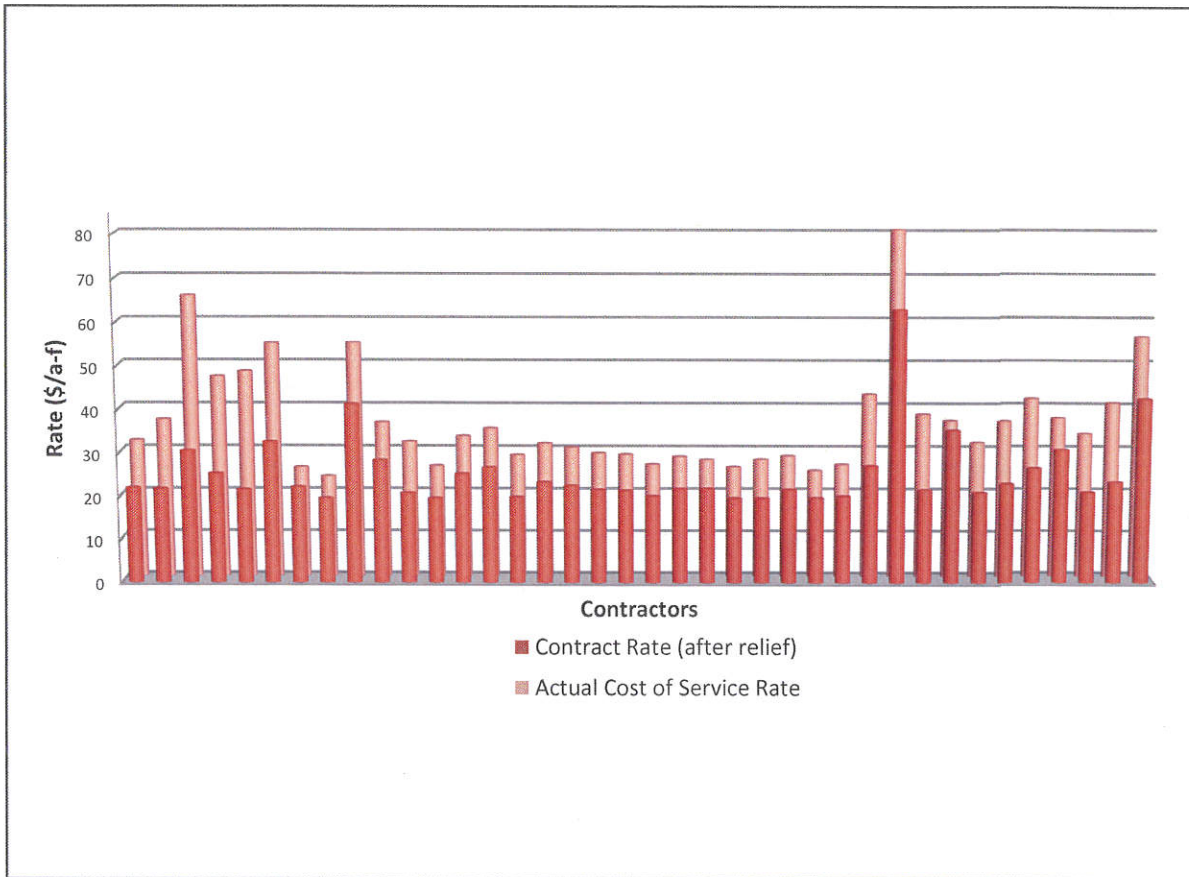
Figure 1. 2015 CVP Agriculture Contractor Rates



Source: Bureau of Reclamation, Mid Pacific Region, 2014 Ratebooks

Notes: Does not reflect charges for all contractors (including some contractors receiving special rates). Does not reflect additional restoration fund surcharges of \$10.07 and \$7.00 per af for certain contractors.

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pay.”

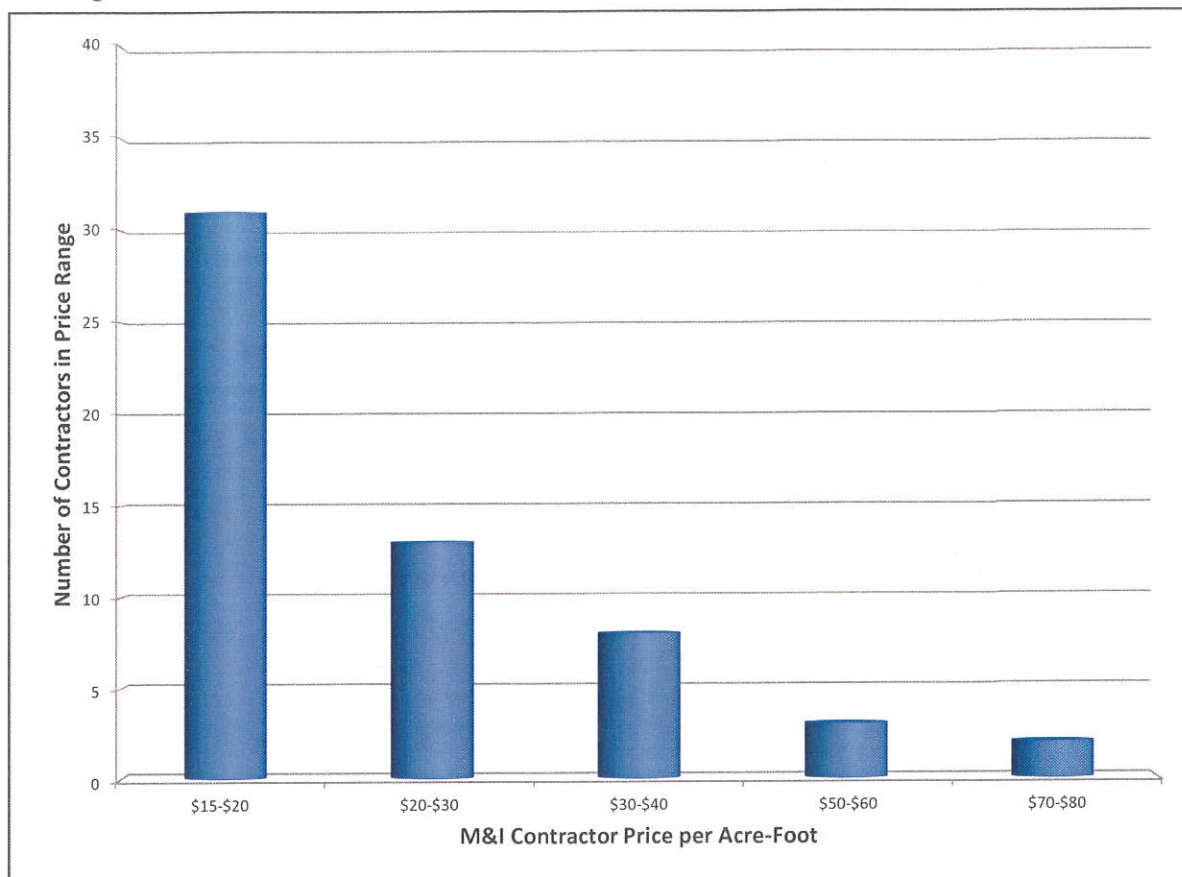
Figure 2. Repayment Relief for Eligible CVP Contractors, 2014

Source: Bureau of Reclamation, Mid Pacific Region, 2014 Ratebooks.

Notes: Does not reflect additional restoration fund surcharges of \$10.07 and \$7.00 per af for certain contractors. For presentation, individual contractors on the horizontal axis are not shown here. These contractors appear in the order in which they are listed in Reclamation's ratebooks.

M&I contractors are the other primary users of CVP water. These contractors pay rates based on a combination of construction costs that are allocated to M&I purposes, plus interest, as well as costs for annual operations and maintenance. According to Reclamation's 2015 ratebooks, the estimated rates per acre-foot for the 60 CVP M&I Contractors in water year 2015 ranged from \$15 to \$76 per acre-foot, and average \$26.02 per acre-foot.¹⁴ Estimated rates for CVP M&I contractors are displayed below in **Figure 3**.

¹⁴ Bureau of Reclamation, *Schedule of M&I Contract and Cost of Service Water Rates per Acre-Foot by Contractor, 2015 M&I Water Rates, Schedule A-1, 2015*, http://www.usbr.gov/mp/cvpwaterrates/ratebooks/mi/2015/M&I_2015_Sch_A-1_F.Z17.pdf.

Figure 3. Breakdown of 2015 CVP Municipal and Industrial (M&I) Contractor Rates

Source: Bureau of Reclamation, Mid Pacific Region, 2015 Ratebooks for Municipal and Industrial Contractors, Ratebook A-I.

Notes: Does not reflect additional restoration fund surcharges of \$20.14 and \$41.97 for some contractors.

As noted above, it is not possible to authoritatively estimate a cost per acre-foot for all CVP water due to complexities associated with the calculation of a single amortized construction figure for the whole project, as well as projected figures for project yield. However, a brief review of the costs and deliveries associated with CVP facilities is illustrative. In 2013 Reclamation estimated the original development cost of the CVP at \$4.22 billion, and the average annual cost for project operations and maintenance in recent years has been approximately \$162 million.¹⁵ While there are no reliable estimates of the CVP's yield, one could hypothetically assume that the majority of the project's "deliveries" could serve as a proxy for yield.¹⁶ Even taking into account recent drought years and delivery restrictions, Reclamation estimated that from 2008 to 2013 the CVP

¹⁵ Construction cost estimate based on Bureau of Reclamation, 2013 Statement of Project Construction Cost and Repayment: Central Valley Project. Operations and maintenance estimate based on CRS analysis of Reclamation funding data.

¹⁶ There are a number of reasons why "deliveries" cannot be considered tantamount to "yield" for the Central Valley Project. For example, Sacramento River water settlement contractors north of the Bay Delta region, and San Joaquin river Exchange contractors south of the Delta, were diverting water prior to the CVP, thus it would likely be inaccurate to attribute their deliveries from the CVP to that project's existence.

averaged about 5.3 million af in deliveries for authorized uses (e.g., irrigation, urban, and fish and wildlife).¹⁷ While the actual portion of deliveries attributable to the CVP (i.e., project “yield”) would be a lesser amount, a conservative estimate of project yield would nonetheless be several million acre-feet per year. For costs, the necessary addition of interest to construction costs for the CVP would likely increase the project’s overall costs. However, even after accounting for all of these changes, the project’s low original development cost (compared to current projects) combined with its significant yield/deliveries, would appear likely to result in an extremely low annual \$/af of yield calculation compared to other options.

4. Question: What is the estimated range of costs of water (per acre-foot) for desalinated water about to be produced in California?

Response: Costs for desalination are highly variable and depend on a number of factors.¹⁸ The most important of these is usually the cost of energy, which is a critical determinant in assessing the viability of desalination. Other factors, such as site-specific costs related to salinity of water and/or disposal costs, acquisition of land if not already owned by a utility, as well as size of the plant, plant technology and design, and delivery infrastructure costs may also factor significantly into the cost of desalination projects. Further, many cost estimates for desalination assume that the plant will operate at near or full capacity, but if this is not the case, operational costs may increase significantly.

Estimates of the range of costs for desalination have also varied over time, further demonstrating the dynamic nature of project economics. In the 1990s, estimated costs for desalination were reportedly estimated at \$2,000/af, but earlier this decade improved technology and lower energy costs decreased costs to near \$1,000/acre-feet.¹⁹ More recent assessments by the State of California cited estimated costs in the range of \$1,600 to \$3,000/af.²⁰ The Carlsbad Desalination project in San Diego, expected to be the largest project of its kind in the western hemisphere, is projected to have costs ranging from \$2,014 to \$2,257/af, including delivery infrastructure.²¹ This is reported to be at the upper end of costs for desalination projects.²²

5. Question: What is the range of water costs per acre-foot for water transfers in California?

Response: There is no formal accounting for water transfer prices by the state of California. Thus, CRS was only able to compile information on water transfer costs based on available press accounts and anecdotal information, and is not able to confirm prices paid in actual transactions. Anecdotal information on water transfer prices suggests that they too are highly variable, and depend on factors such as the region or regions in which they take place, hydrologic conditions and water allocations associated with specific water years, the timing of the transfer during the water year, among other factors. Further,

¹⁷ Bureau of Reclamation, *CVP Contract Water Delivery Information*. It should be noted, however, that 3 of the years in this time period were drought years. Historically, the CVP has delivered between 6 and 7 MAF. http://www.usbr.gov/mp/PA/water/docs/CVP_Water_Deliveries.pdf.

¹⁸ The estimates discussed here are for desalination of seawater (rather than brackish groundwater). Costs for desalinating brackish groundwater may be lower. For more information about desalination, see CRS Report R40477, *Desalination and Membrane Technologies: Federal Research and Adoption Issues*, by Nicole T. Carter.

¹⁹ WaterReuse Foundation, *Practical Solutions for Water Scarcity*, Washington, DC, 2014.

²⁰ *California Water Plan*, Vol. 3, Ch. 10, pp 10-37.

²¹ San Diego County Water Authority, Carlsbad Desalination Project. <http://www.sdcwa.org/carlsbad-desal>.

²² WaterReuse Foundation, *Practical Solutions for Water Scarcity*, Washington, DC, 2014. p. 24.

available information and accounts on transfer prices tend to lag behind actual purchases. Thus, information on current water transfer prices is largely unavailable at this time.

In general, in-basin water transfer prices north of the Delta are less than they are in other areas of the state, and in-basin transfers are less costly than interbasin transfers (e.g., north to south). Although there is no formal accounting for water transfers in California, news accounts in 2014 reported costs ranging from \$325 to \$2,000 per acre-foot, depending on the location of the transfer. For example, one article noted 2014 water transfer prices ranging from \$1,000 to \$2,000 per acre-foot in the Central Valley, with a price of \$1,100 per acre-foot for transferred water reported by Westlands Water District and \$1,000-\$1,800 per acre-foot reported by individual farmers in the same area.²³ Costs for transfers by some Sacramento Valley growers in the Feather River area (i.e., north of the Delta) were reportedly less, but have been noted to be increasing significantly over time during current drought conditions: these contractors were noted to receive \$200 per acre-foot for their water in 2012, \$500 per acre-foot in 2014,²⁴ and were reportedly planning to charge \$700 per acre-foot for this water in 2015, assuming certain thresholds were met and water was available for transfer.²⁵ Finally, some in-basin 2014 transfers were reportedly as low as \$325 per acre-foot.²⁶

6. Question: What is the estimated cost of water (acre-foot) for the water that is used for the refuges in the Central Valley?

Response: Pursuant to Section 3406(d) of the Central Valley Project Improvement Act (CVPIA), water provided to national wildlife refuges in the Central Valley is provided from CVP yield, and costs for this water are shared between the federal taxpayer, irrigation, M&I users, commercial power, and the state of California. While Reclamation does not publicly report on the cost per acre-foot of this water, the estimated cost per acre-foot for refuge water provided by the CVP would likely be similar to other CVP water rates, depending on the CVP Unit or service area in which the refuge is based.

²³ Alison Vekshin, "California Water Prices Soar for Farmers as Drought Grows," *Bloomberg Business*, July 24, 2014. <http://www.bloomberg.com/news/articles/2014-07-24/california-water-prices-soar-for-farmers-as-drought-grows>.

²⁴ For some of these contractors, amounts reportedly ranged as high as \$600 an acre-foot in 2014, if Delta carriage loss was below certain levels. Presentation by Andrew Hitchings, "Key Aspects of Transfers in 2014." Summary materials available at: <http://mavensnotebook.com/2015/01/14/the-future-of-water-transfers-after-the-2014-drought/>. Hereinafter, "Hitchings Presentation."

²⁵ Heather Hacking, "Sacramento Valley Water Transfers: Prices Spike, Amounts Uncertain," *Chico Enterprise Record*, March 11, 2015.

²⁶ Hitchings Presentation.